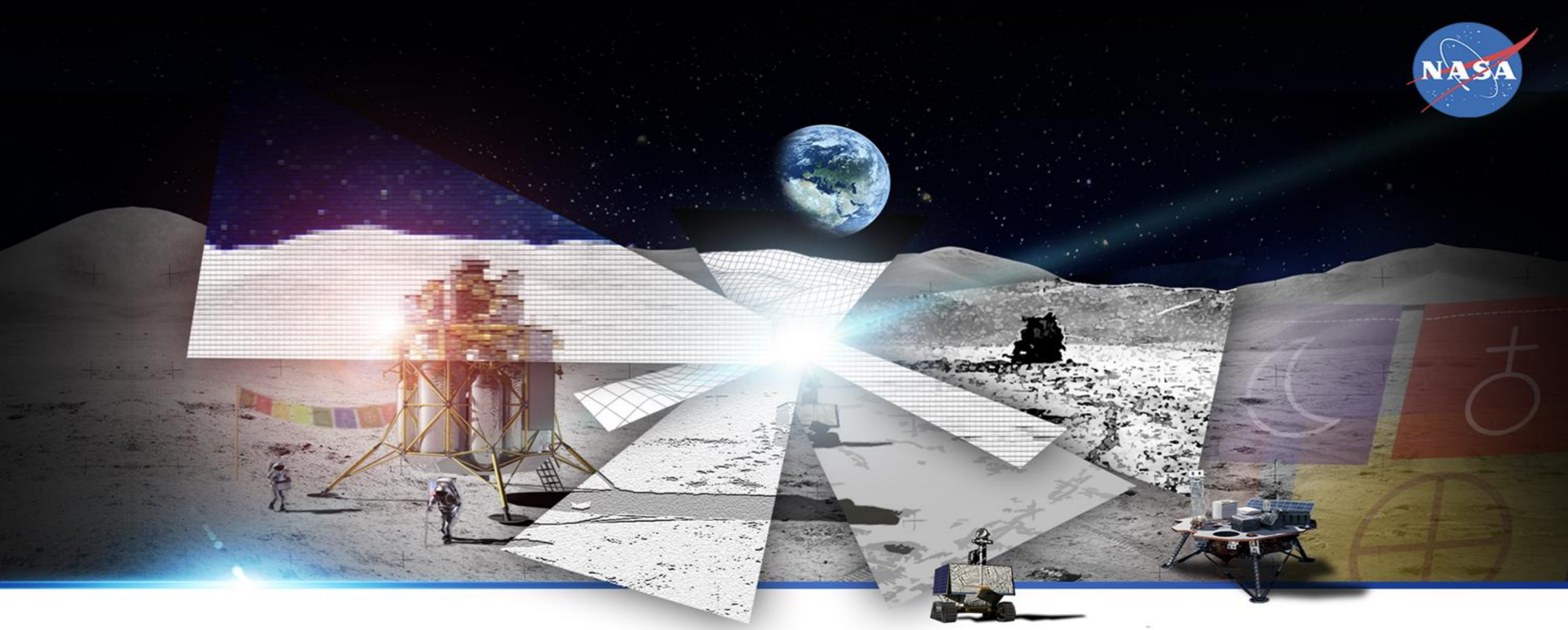


The A-B-C's of Building the Artemis Base Camp

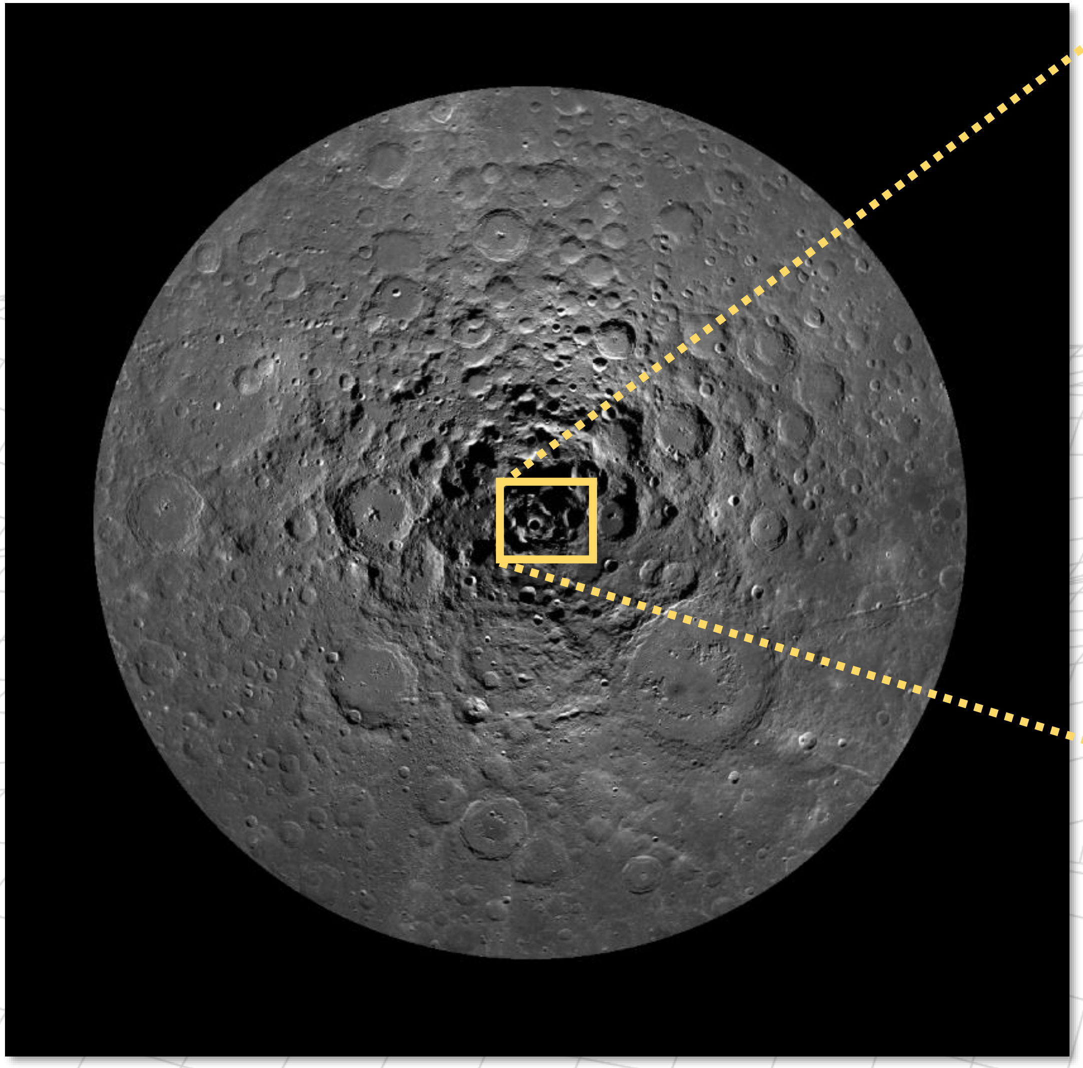
Dr. Ruthan Lewis, Ph.D.

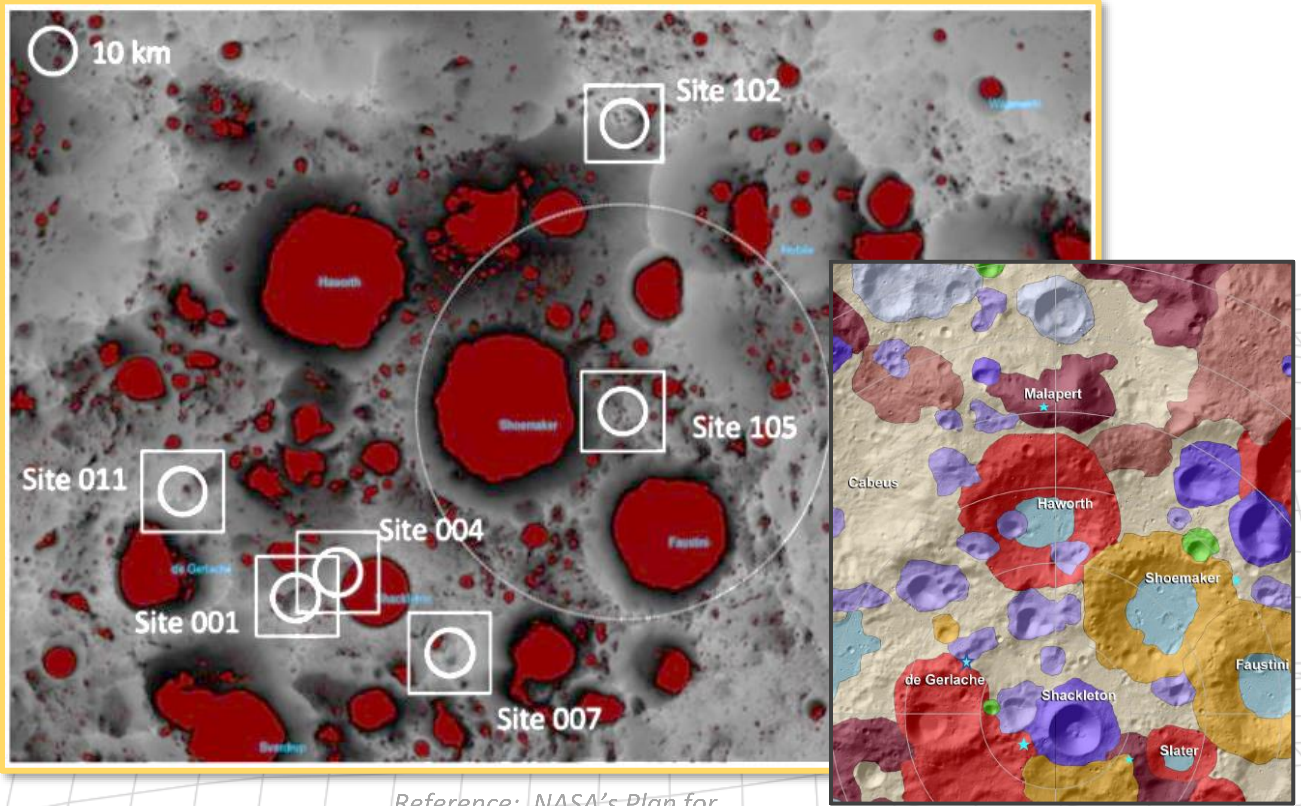
June, 2022

"Too low they build, who build beneath the stars"

- Edward Young

Potential Artemis Base Camp Sites at the Moon's South Pole





Reference: NASA's Plan for Sustained Lunar Exploration and Development

Base Camp

Serves as the core and initial central point /hub for near-term and long-term lunar exploration

Base Camp Functions

- Is the “seed” and operational origin and core for site operations, utilization, potential growth or expansion, and development
- Comprised of elements that provide logistics or other support
- May evolve to provide necessary support and services for future operations

Human Systems
Shelter
Life Support
Extravehicular Activity

Support and Utilities
Communication
Navigation
Power
Logistics
Repair and Maintenance
Waste

Mobility
Surface vehicles
Travel Corridors

In-Situ Resource Utilization
Mining
Processing
Storage
Distribution

Launch and Landing
Crew
Cargo and Payload

Surface Operations
Surface Preparation
Science (geo, bio, physical)
Technology

Site Analysis, Design, and Planning

Organization

Efficiency

Access

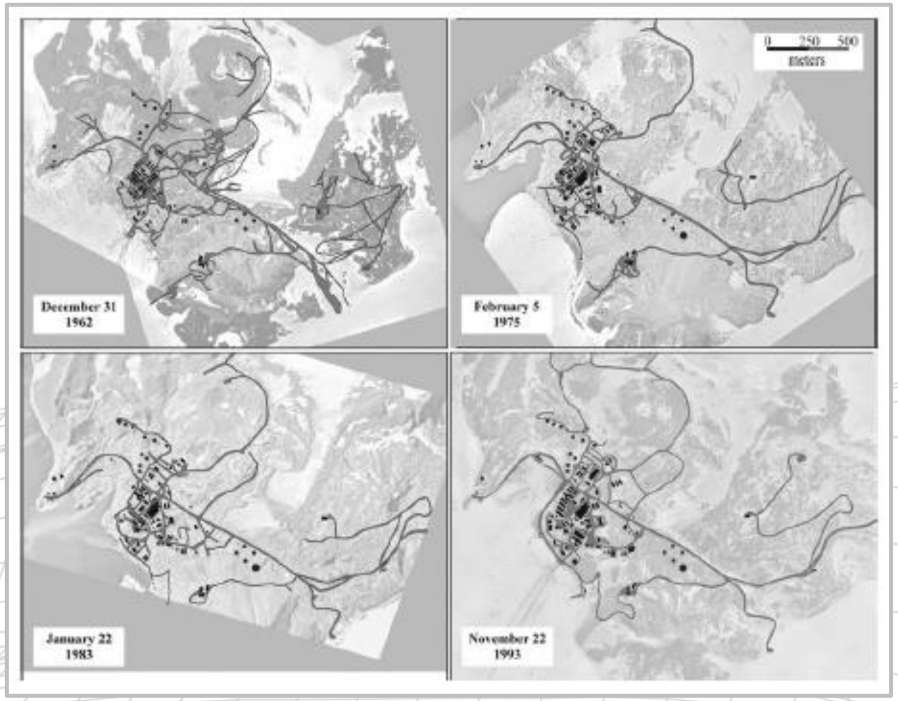
Safety

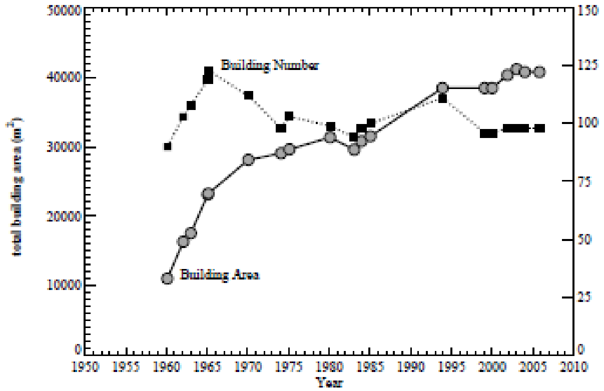
Protection

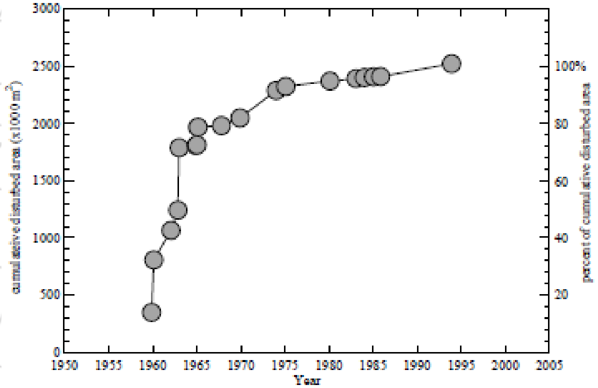
- A system integrating process that helps allocate functions to derive efficient utilization of the land and resources at one's disposal
- Emphasizes the character of the site(s) to effect site selection and construction to support surface operations
- Expresses relationships between built elements and the environment
- Presents orientation and temporal variations and degrees of sustainability over the lifecycle of the site or sites singly and as a system

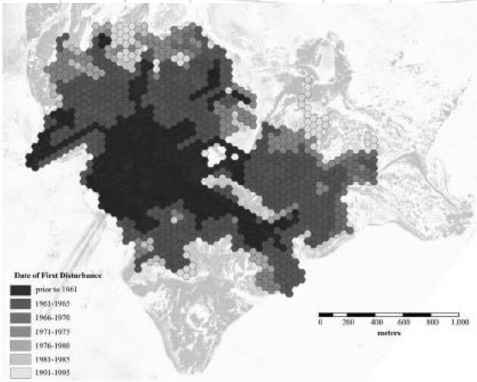
A site plan is an ordering and arrangement of elements within the environment, reflecting spatial and temporal relationships and interactions to achieve objectives

An Antarctica example of why site planning is important – Don't Destroy What You may Desire to Explore in the Future









Logistical Efficiency + Resource Efficiency + Quality of Life

Site

- Fire Protection Storage and Distribution
- Electrical Distribution
- Pedestrian/Vehicular circulation

Buildings

- arrangements to increase operational efficiency and function

Logistics Management

- optimize warehousing and delivery processes, while reducing footprint

Information Technologies

- decrease complexity and increase reliability

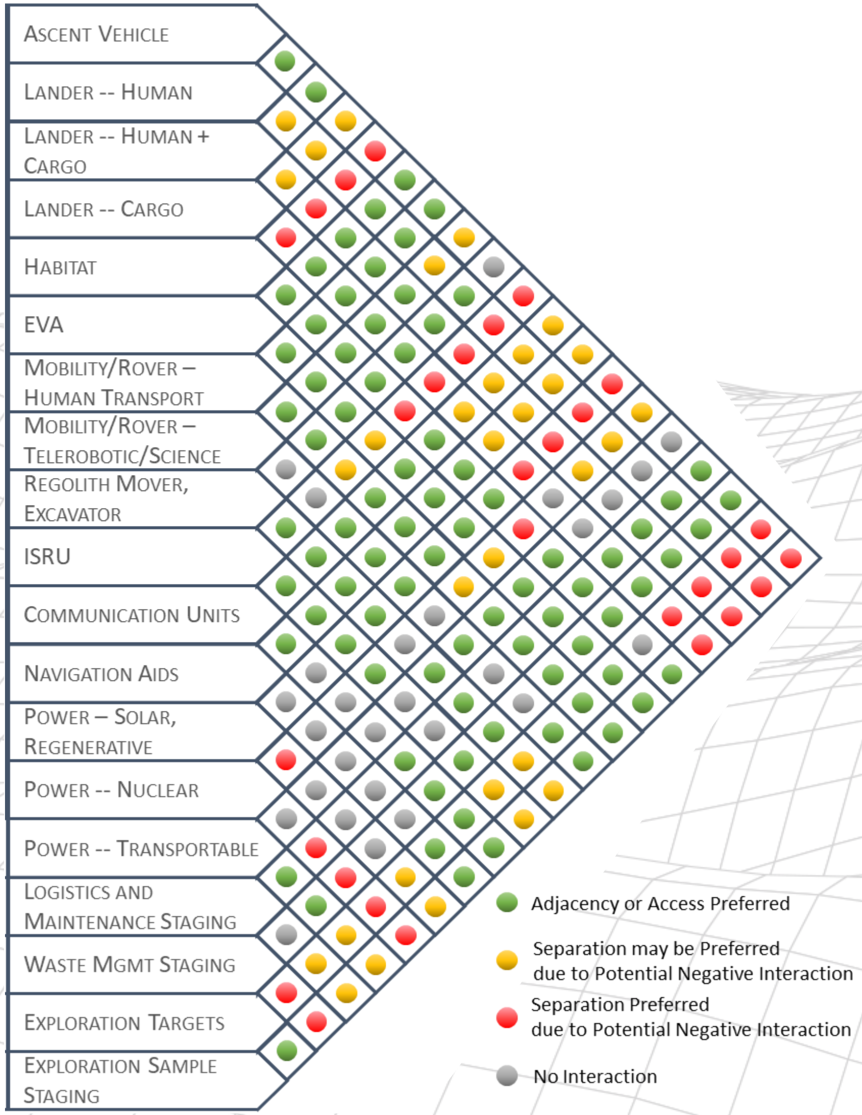
Energy Conservation

- increase facility efficiency, while preparing for renewable energy sources

Quality of Life

- improve both the living and working experience

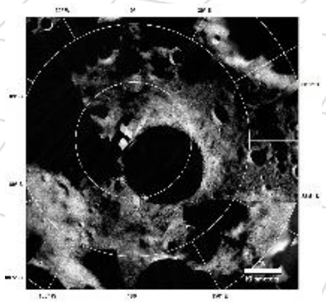
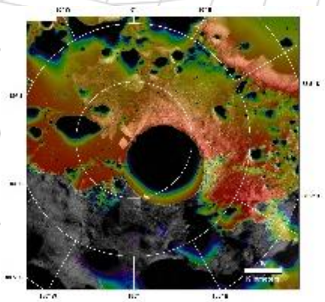
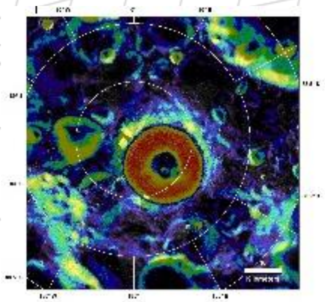
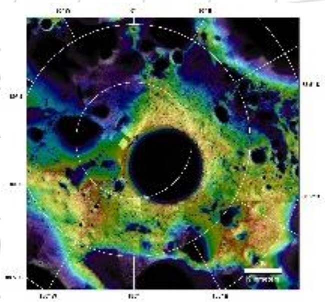
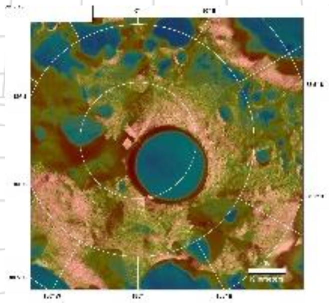
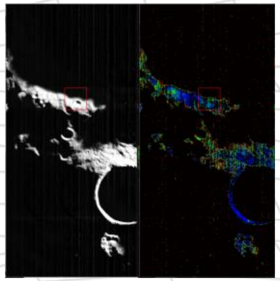
Surface Element Interactions – Do’s and Don’ts



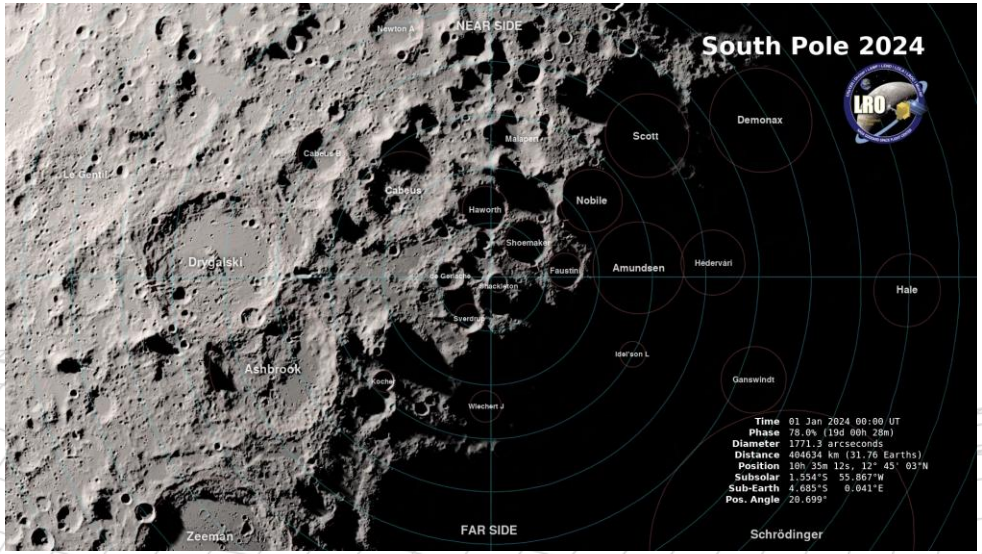
- Distance and elevation between lander and ascent vehicles and the habitation area will account for mobility (rover and EVA) capabilities, plume surface interactions, obstacle avoidance, and visibility
- Landing area components will be positioned to accommodate expected landing approach paths (obstacles, shadows, etc.)
- Reusable landing areas and ascent areas may be utilized to reduce plume impingement affects from repeated landings/ascents and reduce footprint to increase logistical and resource efficiencies
- Moving landers/ascent vehicles from landing/ascent areas/pads will be considered
- Mobility and circulation paths will be arranged and prepared to minimize dust at habitation entry/exit points
- Mobility and circulation paths will be arranged for avoidance of obstacles such as power cables, topography, boulders, etc.
- Mobility and circulation paths will be arranged to accommodate placement of logistics, payloads, and waste management provisions
- Mobility and circulation paths will conform to extravehicular activity sighting constraints to/from landers, habitats, etc.
- Surface elements will be arranged to minimize impact of shadows on co-located surface elements
- Surface elements will be arranged to utilize available natural light/illumination
- Surface elements will be placed to accommodate observations from different vantage points
- Surface elements will be arranged to make effective use of natural and human-induced thermal conditions
- Surface elements will be arranged to effectively utilize and minimize disruption of communication signals and minimize impact caused by radio frequency signals
- Surface elements will be arranged to take advantage of natural radiation barriers including topographical features such as hills, berms, craters, tubes, etc.
- Logistics and waste management provisions near to habitation areas are not to interfere with access to the habitat(s) or impact the environment
- Surface elements will be arranged for efficient access to natural and emplaced resources, functional areas, and exploration areas

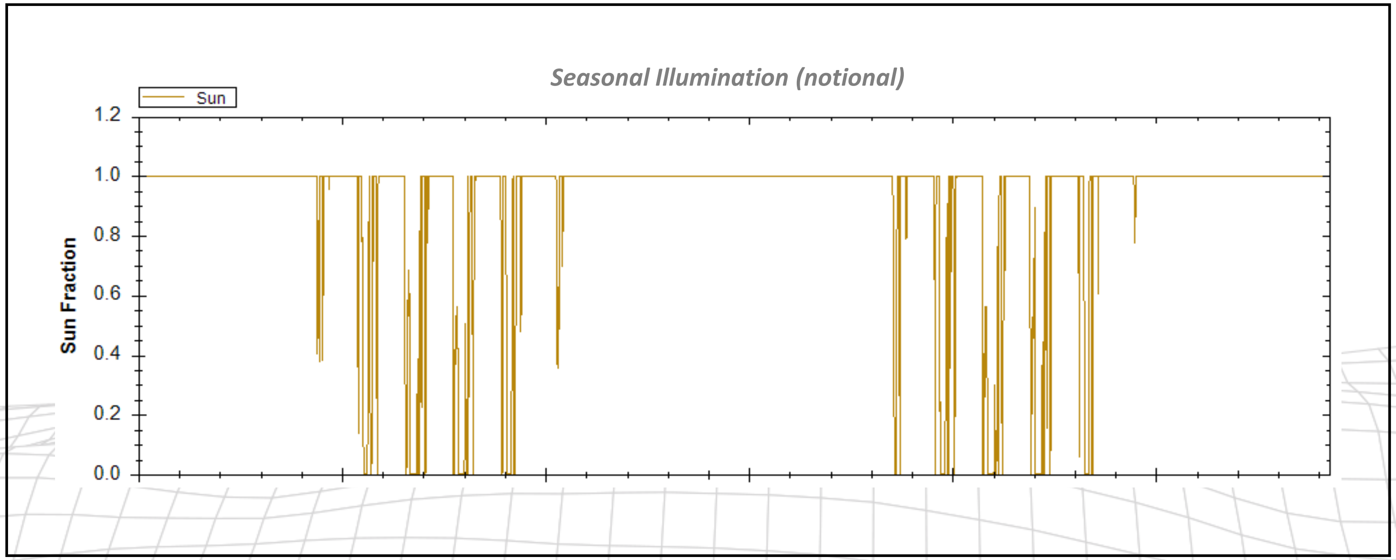
Environmental and Operational Factors/Variables

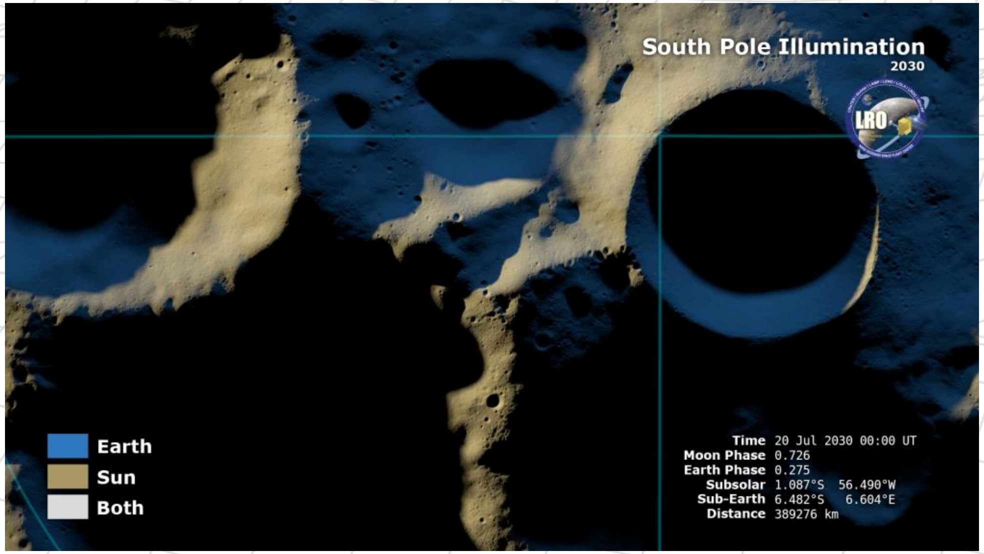
- Topography and Contours, Altitude, Elevation
- Terrain and Geomorphology
- Dimensions and Area
- Illumination, Light/Dark (sun/shade) seasonal patterns
- Glare, Reflection, Albedo
- Climate: space weather, temperature cycles
- Radiation: natural, induced
- Spacecraft Induced Ejecta, Plume Impingement
- Instantaneous Impact Point
- Earth Viewing

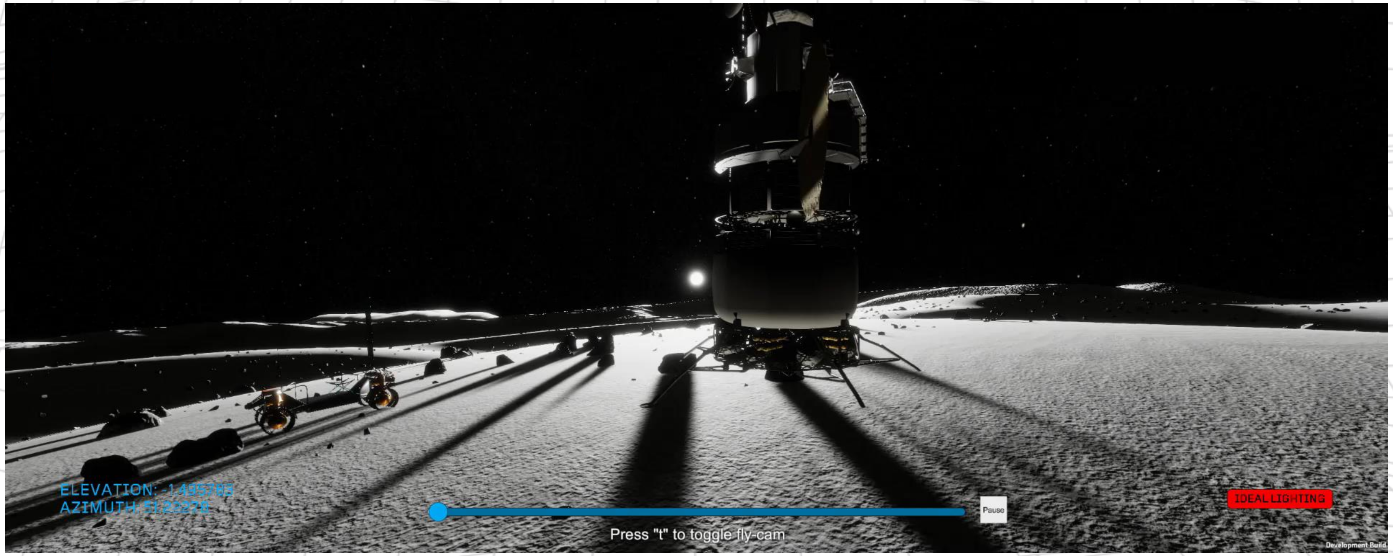







Fundamental planning question: Where's the greatest concentration and duration of light?

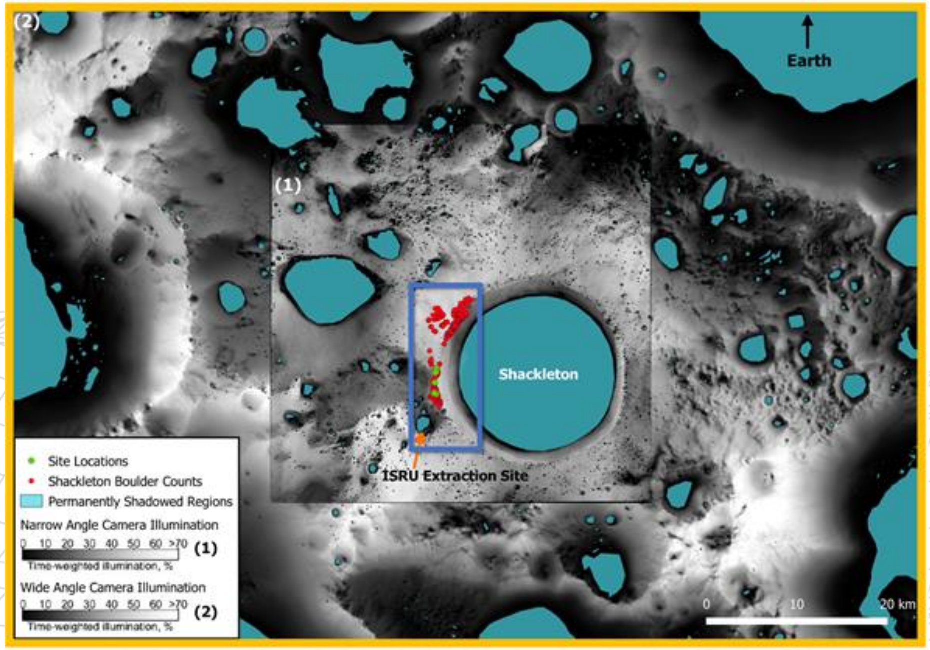


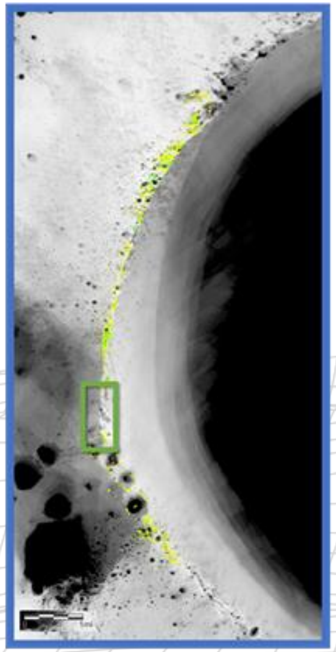


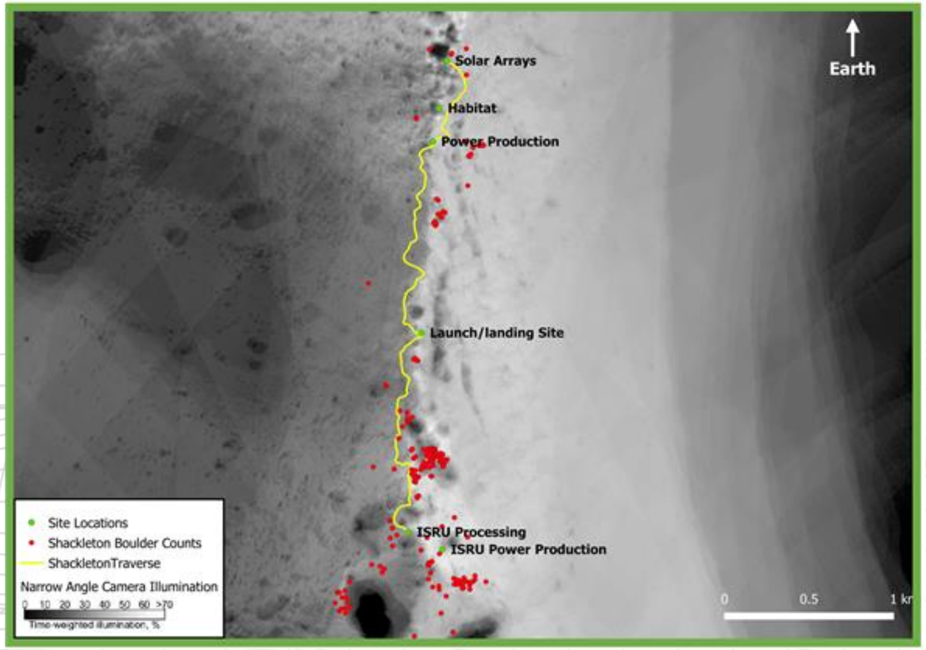




Scale and Viewpoints







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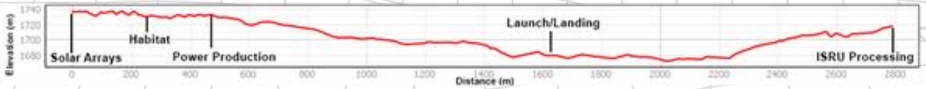
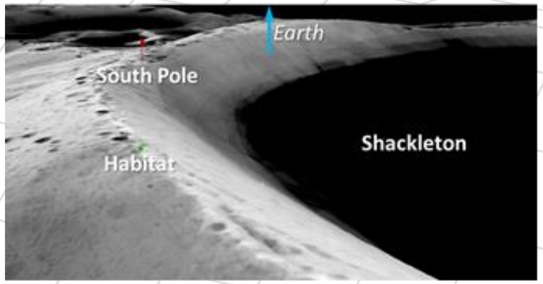
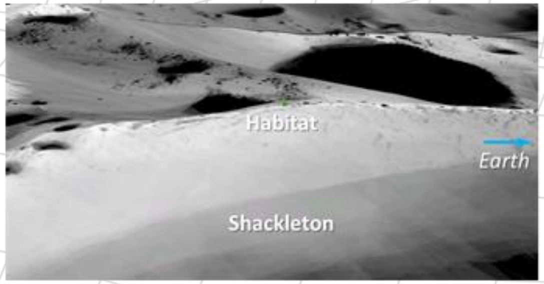
- Speyerer, E. and Robinson, M., "Persistently illuminated regions at the lunar poles: Ideal sites for future exploration." Icarus 222 (2013): 122-136.

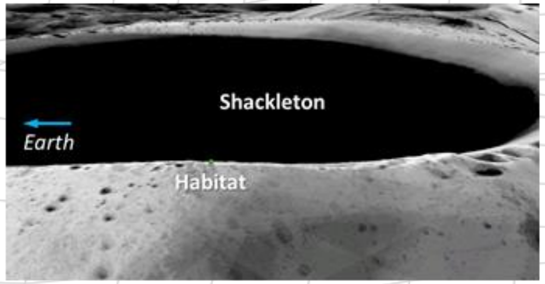
Slopes:

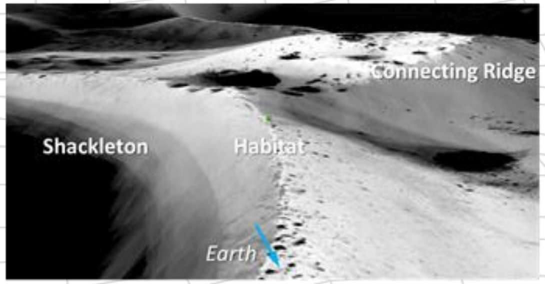
Green = less than 5 degrees
Yellow = 5-10 degrees











Evaluating a Site – Will it Achieve Objectives?

	FIGURE OF MERIT
From McMurdo Master Plan	**Respect the Knowledge of the Existing Environment, Weather Conditions and Terrain**; environmental compatibility (natural and human-induced)
	Reduced Footprint -- to increase logistical efficiency, resource efficiency, and to reduce the reliance upon vehicular traffic
	Walkability -- to reduce reliance upon vehicles, their associated staffing and maintenance, improve safety through reduced pedestrian / vehicular conflicts
	Self Sufficiency in Phasing – the station is fully functional upon completion of each phase, without reliance upon the implementation of subsequent phases
	Simplicity and Standardization -- to promote ease of operations and maintenance, minimizing the reliance upon specialists
	Flexibility and Adaptability -- to allow for the evolving nature of inquiry; includes modularity
	Reliability -- to reduce maintenance staffing and associated costs
	Strategic Redundancy -- to enhance both on-going operations and disaster recovery
	Integrated Social Spaces -- to enhance collaboration and the sense of community
	Consciously Revisit the Master Plan on a Regular Interval -- is a living document; confirm direction of the plan as needs of research, and tech change
Additional Lunar-Applicable (recently derived)	**Availability of Energy Resources**
	Access to Resources (natural and emplaced), Functional, and Exploration Areas within Capabilities
	Frequency of Access
	Productivity of End-Resources
	Controllability, Manageability
	Science Value
	Level of Infrastructure, Utilization of Infrastructure
	Level of Crew Risk, Impact on Crew
	Mars-forward Applicability
	Human-Robotic Interaction
	Extensibility, Future Usage Accommodation
	Commercial Feasibility

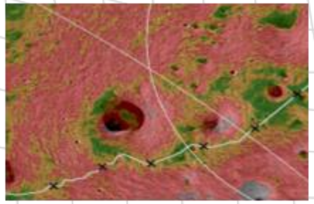
The A B C's of Building the Artemis Base Camp
Site Analysis, Design, and Planning Process and Analysis

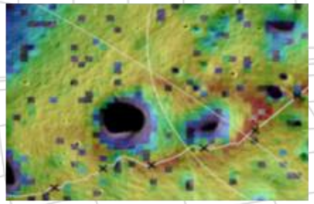
Process

- Describe the objectives of the site(s)
- Define the "Figures of Merit" and metrics to measure the objectives
- Identify the functions and actions to be performed, when, and for how long
- Identify constraints and limitations of the functions
- Assess how multiple functions will interact
- Characterize the environment
- Derive and apply "test" scenarios that represent the integration of the objectives and placement of surface assets and facilities under expected environment conditions
- Compare site options at different scales, perspectives, and visualizations
- Identify knowledge and technology gaps – knowns and unknowns
- Identify risks

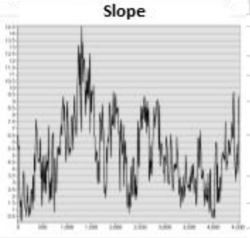
Site Analysis, Design, and Planning Objectives -- Encore

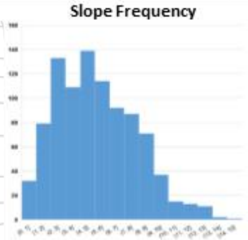
- Establishes arrangement of surface facilities and transportation corridors to exploration regions, and methods for mitigating cross-contamination and site preservation
- Facilitates efficient transport, needed resources, and operations
- Promotes efficiency of use of the lunar environment
- Readies us for long-term lunar presence as well as Mars exploration
- Increases exploration value and return

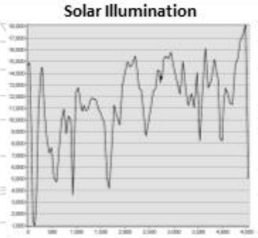




Least Cost Path Analysis (notional)







Questions?